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XIV.—*Considerations on the Surviving Refugees in Austral Lands of Ancient Antarctic Life.* By C. HEDLEY, F.L.S., Assistant in Zoology to the Australian Museum *.

To ordinary readers the most desolate region imaginable is that within the Arctic Circle. Yet the intrepid explorers who have furthest penetrated into the northern wilds encountered there bears, wolves, musk-oxen, walrus, seals, and other mammals, and saw flocks of birds steering northwards beyond the utmost limit of discovery.

Infinitely more desolate is the mysterious and perhaps impenetrable Antarctic continent or archipelago. For aught we know, here may tower loftier mountains than geographers have marked in the Himalayas. From the ship's deck voyagers † have descried volcanic peaks trending into an interior which extends as an unbroken sheet of ice and snow. Beyond the beach its whole surface hardly now nourishes a single animal or plant; for the lichen reported by Borchgrevink ‡ from Possession Island and Cape Adare alone

* From an advance proof communicated by the Author, having been read before the Royal Society of New South Wales, August 7, 1895.

† M'Cormick, "A Sketch of the Antarctic Regions, embracing a few Remarks, Geographical and Ornithological," *The Tasmanian Journal of Natural Science*, i. p. 246.

‡ 'The Geographical Journal,' vol. v. June 1895, p. 583.

constitutes the recorded terrestrial flora. Enveloped in an atmosphere of universal death, wrapped in its closely clinging cerements of ice and snow, the one expression of the Antarctica of to-day is that of lifeless silence*.

But it was once otherwise. Not only may a naturalist assert that here stately forests once stood, streams once rippled, and green fields smiled, but he can picture what trees composed those forests, of what kind were the frogs and snails they sheltered, and of what form were the fish that swam in those streams.

Early scientific travellers† remarked that the converging continental masses of the southern world held as common stock certain forms of life. Closer enquiry elicited that these common forms were primitive, often isolated types, survivors of some ancient population overwhelmed and slaughtered by invaders from the north. South Africa was found to stand somewhat apart from the closer bond which united Tasmania and Australia to New Zealand and South America, while New Zealand is in turn poorer actually, if not comparatively, than Tasmania in South American affinities.

"Community of type," writes Dr. Gill‡, "must be the expression of community of origin . . . and recent palæontological finds indicate that even the Thylacinids (or, at least, forms resembling them) were formerly natives of southern America. . . . The freshwater fishes [of New Zealand] must have been derived from the same common source as those of the isothermal portions of Australia (of course including Tasmania) and southern America. There may not have been a continuity of land at any one time between South America, Australia, and New Zealand, but at some remote period in the past it is at least possible that there was a region in which Galaxids and Haplochitonids were developed, and subsequently representatives of those families might have found their way into the regions where they now abound."

An enumeration of the genera common to South America, New Zealand, and Tasmania, and therefore probably of Antarctic origin, would exceed the limits of this paper. Forbes§ quotes numerous instances; and for more ex-

* For the best physical and geographical description of Antarctica see Murray, 'The Geographical Journal,' vol. iii. pp. 1-27.

† J. D. Hooker, "On the Huon Pine &c.," London Journal of Botany, vol. iv. 1845, pp. 137-157.

‡ "A Comparison of Antipodal Faunas," National Academy of Sciences, vol. vi. p. 108.

§ "Antarctica, a supposed former Southern Continent," Natural Science, iii. pp. 54-57.

haustive data monographs of most groups of animals and plants of these countries may be consulted*.

We may compare the shattered biological monuments of Tasmania and South America to the broken columns found by Oriental travellers in the ruined and deserted cities of a vanished civilization; and as an archæologist may restore from such fragments the fallen temples or disused aqueducts, so may a naturalist trace the missing arches of life that once spanned the gap. Some of the efforts to do so may be here reviewed.

Prof. Hutton has conjectured† that such a bridge spanned the South Pacific from Chili to Samoa, and thence to New Zealand. Claiming South-American relations for the New-Zealand fauna and flora, he accounts for their entry into New Zealand by this assumed bridge. Against Prof. Hutton's arguments it may be urged that, though the relation of New Zealand to South America is indisputable, it is less than between the latter and Tasmania, and that the demand for a former union may be satisfied by supposing an approach but not a connexion with Antarctica. The sole supports of the theoretical transpacific bridge are the difficulties it is believed to explain. A biologist might object that, *had such a bridge existed, New Zealand being at the furthest extremity, ought to contain fewer South-American affinities than do intermediate Polynesian islands*, like Samoa or Tahiti, lying nearer to the source. On the contrary, these islands are devoid of such. And a geologist might say that this supposed bridge was discordant with the main orographic structure of the region.

* For fungi see Darwin, Voy. 'Beagle,' p. 236; mosses, Mueller, Trans. N. Z. Inst. xxv. p. 428; grasses, Buchanan, 'Indigenous Grasses of New Zealand'; trees, Kirk, 'The Forest Flora of New Zealand'; lichens, Shirley, Proc. Roy. Soc. Queensland, vol. x. p. 54; earthworms, Beddard, 'A Text-book of Zoogeography,' p. 60; isopods, the same, p. 173; crayfish, Parker, N. Z. Inst. xix. p. 154; fluviatile mollusca, Hedley, P. L. S. N. S. W. (2) viii. p. 507, and ix. p. 464; trematodes, Haswell, 'A Monograph of the Temnocephalæ,' Macleay Memorial Volume; ants, Emery, 'Nature,' Aug. 22, 1895, p. 400; planarians, Dendy, Trans. New Zealand Inst. 1895, p. 177; diptera, Skuse, Proc. Austr. Assoc. Adv. Science, i. pp. 526-540, and Osten Sacken, Berliner entomolog. Zeit. Bd. xxx. 1886, Heft ii. pp. 153-187; lepidoptera, Meyrick, various papers, Trans. New Zealand Institute. Mr. Skuse has drawn my attention to the interesting South-American and Australian distribution of *Stigmodera* and other genera grouped around it, as enumerated in Gemminger and Harold's 'Catalogus Coleopterorum,' tome v. pp. 1392-1405. When defects in the current classification of invertebrates are amended, the likeness between southern faunas will grow more apparent.

† "On the Origin of the Fauna and Flora of New Zealand," New Zealand Journal of Science, ii. pp. 1-249; and Ann. & Mag. Nat. Hist. (5) xiii. p. 426.

Its relics are detected by Prof. Hutton in an abyssal area two thousand fathoms deep, which only in strained language can be termed a "plateau." Of where he supposes that it lay Geikie * writes: "so abruptly does the continental plateau rise from the ocean trough, that a depression of the sea-level or an elevation of the plateau for ten thousand feet would add only a narrow belt to the Pacific coast between Alaska and Cape Horn." Much of the biological and geological data on which Prof. Hutton's paper was based have since been refuted or withdrawn.

Another answer to the question at issue is tendered by Dr. H. O. Forbes †. After a lucid summary of the kinship of austral life observed by earlier naturalists and of facts collected by himself in the Chatham Islands, he constructs an immense hypothetical Antarctic continent to explain these problems.

The impression left on my mind by a careful study of this paper is that a foundation so slender is insufficient to bear a superstructure so vast. No geological era is assigned for the map of Ancient Antarctica accompanying the article. To this area the Mascarene Islands appear to be attached chiefly upon the strength of an extinct bird of dubious lineage. The difficulties of the change from the climate of primeval Antarctica and the change in the depth of circumpolar seas are not explained, or, indeed, the changes proved. The Antarctic fauna and flora, so far as surviving fragments allow us to reconstruct them, do not suggest that wealth of forms which so wide an extent of land should have developed. A much harsher climate would have prevailed over Forbes's broad continental area than over a chain of islands or a narrow strip of land. *Had the conditions indicated by Dr. Forbes once existed, then each of the southern land-masses should have preserved an equal heritage of Antarctic life*, which is not the case. A sharing of population may not be invariably cited (as it is in this paper) as indicative of former land-passages, for it has been clearly demonstrated in the case of the Azores and Galapagos that considerable immigration may occur across wide expanses of ocean.

Mr. H. A. Pilsbry has remarked ‡ that "the presence of very similar forms in southern South America and Tasmania and New Zealand has been accounted for by the hypothesis of a former more extensive Austral continent or 'Ant-

* Address Geograph. Sect. British Association, 1892, p. 796.

† "The Chatham Islands, their relation to a former Southern Continent," vol. iii. Supplementary Papers, Royal Geographical Society, 1893.

‡ 'Guide to the Study of Helices,' p. xxxix (Philadelphia, 1895).

arctica,' which may have been supplied with these snails, as well as with certain marsupials, fishes, &c. from Australia, and subsequently became united at Cape Horn, transferring the fauna. The connexion could hardly have been in reverse order, or why should not Edentates and Hystricomorph Rodents have invaded Australia?"

The opposite view, viz. that Antarctica transferred a fauna from America to Australia, is favoured by the facts that the fossil marsupials from the Patagonian Eocene antedate * any fossil marsupials recorded from Australia, that the marsupialia dawn upon the Australian horizon as a highly differentiated group, and that Prof. Spencer has demonstrated † "that the diprotodonts had their origin in the Euronotian region," meaning that their centre of dispersal lay to the south-east of Australia. Von Ihering has suggested ‡ that a large area of South America was separated in Mesozoic times from the remainder, and maintained a distinct fauna and flora. If from this tract, which he terms Archiplata, were excluded, as he holds, placental mammals, it may have peopled Australia with marsupials, and yet not have transferred thence Edentates or Hystricomorph Rodents.

The relation of Antarctica to African lands is a subject on which an Australian student has little chance to form an opinion. Perhaps the faint though real affinity (as shown in the distribution of the mollusks Endodontidæ, Rhytididæ, and Acavinæ) would be explicable on the supposition that before either America or Australia had united with Antarctica,

* This statement is derived from the following data, for which I am chiefly indebted to the kindness of my friend Mr. W. S. Dun, Assistant Palæontologist to the Geological Survey of N. S. W., himself the author of important papers on the subject. The oldest DESCRIBED Australian mammalia are Pliocene, viz. *Ornithorhynchus maximus*, Dun, and *Echidna robusta*, Dun (Records Geol. Survey, N. S. W. iv. p. 119), from this colony. From Victoria Prof. M'Coy has claimed as Pliocene ('Prodromus,' "Palæontology of Victoria," decades i.-vii.) *Phascolomys plocenius*, M'Coy, *Diprotodon longiceps*, M'Coy, *Macropus titan*, Owen, and *Procoptodon goliath*, Owen. Some bones recognized by Johnston (Geol. Tasmania, p. 261) and Tate (Proc. Roy. Soc. N. S. W. 1893, p. 168) as *Halmaturus*, from the Eocene of Table Cape, Tasmania, can hardly be discussed till they have been studied, described, and named. Yet on *à priori* grounds the Diprotodontia can scarcely be supposed to have so far proceeded on the path of differentiation from the radical Polyprotodont stock as to have evolved into *Halmaturus* at the early date of the Eocene; further, the sea-shells of this deposit form an incongruous environment for a wallaby. For a list of the numerous marsupials extracted from the Upper Eocene beds of Santa Cruz, South America, see Zittel, Geol. Mag. x. p. 456.

† Report Austr. Assoc. Adv. Science, 1892, p. 118.

‡ Trans. New Zealand Institute, 1891, xxiv. p. 434.

Africa had already been joined to and broken from it, receiving a colony thence or leaving one there to mix with American and Australian forms when the vicissitudes of continental growth permitted.

In an inquiry * into the distribution of the pond-snail, *Gundlachia*, I lately proposed, as the simplest solution of the problem, that DURING THE MESOZOIC OR OLDER TERTIARY, A STRIP OF LAND WITH A MILD CLIMATE EXTENDED ACROSS THE SOUTH POLE FROM TASMANIA TO TIERRA DEL FUEGO, AND THAT TERTIARY NEW ZEALAND THEN REACHED SUFFICIENTLY NEAR TO THIS ANTARCTIC LAND, WITHOUT JOINING IT, TO RECEIVE BY FLIGHT OR DRIFT MANY PLANTS AND ANIMALS, as the Galapagos received their population from America or the Azores theirs from Europe.

This conclusion was built upon the following evidence. A minimum of land-extension compared with that asked for by Hutton or Forbes was demanded. A milder climate is admitted by geologists, even by those who dispute its cause, to have formerly prevailed in Arctic regions: a mild Antarctic climate should therefore be admissible. Dr. Murray remarks † of the fossils collected by Capt. Jensen close to the Antarctic Circle that they "are probably of a Lower Tertiary age, and they indicate a warmer temperature than now prevails in these high southern latitudes." A cursory survey of a collection of Eocene Mollusca from the Muddy Creek beds of Victoria suggests to me that warmer seas then prevailed. Its wealth of *Cypræa* and *Voluta* points to a tropical climate. I observe there tubes of *Kuphus*, a genus now ranging from Sumatra to the Solomons, whose evidence is corroborated by extinct allies of *Nautilus*. That New Zealand once extended very far south of its present position to or, perhaps, beyond the Macquarie Islands, is granted by all who have investigated the subject ‡. Possibly this southward extension was synchronous with the northward extension indicated § by the range of *Placostylus*. That this southward extension of New Zealand did not, during the marsupial exodus, actually touch the highway between Tasmania and South America, I infer from the fact that such passengers as the venomous snakes, extinct *Palimnarchus*, cystignathous frogs, monotremes, and marsupials failed to arrive in New Zealand. The southward

* Proc. Linn. Soc. N. S. W. (2) viii. p. 508.

† "Notes on an important Geographical Discovery in the Antarctic Regions," Scottish Geographical Magazine, vol. x. p. 195.

‡ Vide Blanchard, 'Comptes Rendus,' 1882, p. 386.

§ Proc. Linn. Soc. N. S. W. (2) vii. p. 335.

prolongation of Tasmania in the direction of Royal Company Island is suggested by the Tasmanian axes described* by Prof. David.

The evidence collected tends to show Antarctica as an unstable area, at one time dissolving into an archipelago, at another resolving itself into a continent.

How this would affect the marine shallow-water fauna has not been previously considered. Under the circumstances I have described, the South Pacific would stretch within a few degrees of the Pole into a deep bight or gulf extending from Tasmania to Cape Horn. Into the western extremity would open the long and narrow tongue of what is now the Tasman Sea. When the climate cooled, the fauna at the head of this Antarctic Gulf, as I propose to call it, would be driven northwards to milder zones. By diverging meridians a similar fauna would reach New Zealand, New South Wales, and Chili†. In a precisely similar manner Darwin‡ has shown how the northern Glacial period drove the same Polar flora by radiating paths to the Alps, Himalayas, and Alleghanies, where they now survive stranded on mountain-tops.

If, when this northward migration occurred, continuous land had reached from Australia to Chili, then none of the fauna of the Antarctic Gulf could have entered either the Indian or the South Atlantic Oceans. We have, however, no warrant for believing that the Antarctic bridge long endured as continuous and contemporaneous land; and that it was pierced by channels is proved by the escape of stray members of that characteristically Antarctic genus *Struthiolaria* to Patagonian coasts (*S. ornata*, Sowerby §), on the one hand, and to Kerguelen (*S. mirabilis*, Smith) || on the other.

The destruction ¶ which the ancient fauna of the Antarctic Gulf has endured, and the length of time which has elapsed since its expulsion, deprives us of much hope of reconstructing it. Since that event, for instance, the genus *Haliotis* has probably altogether grown up as a characteristic feature of

* Presidential Addresses, Proc. Linn. Soc. N. S. W. (2) viii. p. 603, and vol. x. p. 155.

† Cf. "The Occurrence of *Concholepas*, recent only in South America, as a Fossil in Australia," Proc. Roy. Soc. N. S. W. 1893, p. 171.

‡ 'Origin of Species,' Chap. xi.

§ Darwin, Geol. Obs. S. America, pp. 376, 618, pl. iv. fig. 62.

|| Trans. Roy. Soc. vol. clxviii. p. 170, pl. ix. fig. 3.

¶ "We seem [in the Pliocene] to be dealing with the remains of an earlier fauna disappearing rapidly before the conquering host of the recent fauna which had invaded New Zealand some time previously." (Hutton, Macleay Memorial Vol. p. 36.)

the modern Australian molluscan fauna. A search among the more persistent of living types may produce some torn pages of its history. One such is recognized by the writer in *Lucapinella*, whose occurrence in Australian waters is noted *. But palæontology must be chiefly called on to relate the story of the decline and fall of the Antarctic marine fauna.

XV.—*The Male of Apus cancriformis.* By W. BLAXLAND BENHAM, D.Sc. (Lond.), Hon. M.A. (Oxon.), Aldrichian Demonstrator in Comparative Anatomy, Oxford.

IN view of the rarity of the male individuals of this interesting Phyllopodan Crustacean, it may be worth putting on record the occurrence of one amongst the specimens of *Apus* used for examination in the ordinary course of our work in the Zoological Laboratory here in Oxford. The specimens were obtained through Fric, of Prague, from Poděbrady, a town on the Elbe.

Apus is one of the stock examples of parthenogenesis, the bulk of the individuals being females; that males do occur occasionally we know from the observations of Kozubowski, von Siebold, and others; but locality and season appear to have considerable influence on their occurrence. Thus, in 1858, out of 549 specimens of *Apus* collected at Krakau, as many as 154 were males, whereas in 1866 out of 999 collected at Breslau there were only 7 males. Von Siebold's repeated endeavours during several successive years to obtain males are matters of history.

The credit of first describing the male is due to Prof. Kozubowski, who, in 1857, gave an account of the testis, sperm-duct, and spermatozoa (Arch. f. Nat. xxiii.), and laid the foundation for the view which has since then been nearly universally adopted, viz. that *Apus* is parthenogenetic. Up to that period it had been considered hermaphrodite.

It will not be amiss to note that the only external point of difference between the two sexes is the absence in the male of that modification of the sixteenth appendage which results in the female in the formation of an egg-pouch ("oostegopod"); in fact, the sixteenth appendage of the male is precisely like its neighbours, and at its base the sperm-duct opens.

I looked carefully for any appendages which might be

* Proc. Roy. Soc. Vict. 1894, p. 197.